Ballast Water Management System HY^{TM}-BWMS-200

Plan of Land-based Test Project

Tested by: The First Institute of Oceanography, SOA

Witnessed by: China Classification Society

Developed by: Shanghai Hengyuan Marine Equipment Co., Ltd.

Test Base: National Oceanographic Center, Qingdao

September of 2011

Content

1. Description and Purpose of the Project

Shanghai Hengyuan Marine Equipment Co.,Ltd. has put in practice its ISO 9001:2000 quality control system, and it has exercised efficacious quality control over the project in line with its spirit of enterprise, i.e. "Take customer satisfaction as the center, and follow after innovation and continuous improvement".

In order to conduct land-based tests on the ballast water management system HY^{TM}-BWMS developed by the Company as per IMO MEPC.174 (58) resolution given in *Guide Rule for Approval of Ballast Water Management System (G8)*(hereafter referred to as G8), we carries out planning conscientiously and carefully, and we communicates and discuss with The First Institute of Oceanography, SOA, and work out this *Quality Assurance Project Plan*. For this test, we may allocate adequate technological resources, ensure qualified brainpower and efficacious instrument, equipment, standards and specifications may exactly reach the site in time, enhance and strictly carry out process control, put in practice rigorous internal quality auditing, supervision and inspection, keep an open mind to accept multiform Surveillance Inspection and verification to be conducted by the authorities concerned and relevant organizations, and adequately assure the authenticity of outcome quality, test processes, sample data and testing results of the project.

This land-based test covers biological effectiveness, and the test condition and result shall conform to or exceed the requirements specified in G8. The testing items include halonereid, escherichia coli, enterococcus, vibrio cholerae and heterotrophic bacteria.

For implementation of the project, Zhao Bo (general manager of Shanghai Hengyuan Marine Equipment Co.,Ltd. and the principal of ballast water project department) serves as the group leader of quality assurance group, and he may be broadly undertake the quality management and control of the project, and guarantee that the project quality may fulfill the requirements given in G8 in accordance with the standard quality system established as per GB/ T19001-2000.

Shanghai Hengyuan Marine Equipment Co., Ltd.

Chairman: Li Shaolin

September of 2011

2. Project Implementation Unit and Participants

For the full-scale ballast water management system (HY^{TM}-BWMS) developed on the base of filtration + rentschlerizing by Shanghai Hengyuan Marine Equipment Co.,Ltd., an application for type approval is filed to the authorities concerned in China, and a land-based test is conducted as per the requirements of G8.

The First Institute of Oceanography, SOA undertakes the biological activity testing of the project, and it will finish the entire test procedure strictly as per the *Quality Control Plan* and *Quality Assurance Project Plan* specially established for this project in order to ensure the authenticity and accuracy of test process and test results.

Organizations participating in this project includes:

1. The First Institute of Oceanography, SOA: Undertake the test task of the project, and provide the test result and analysis reports.
2. Shanghai Hengyuan Marine Equipment Co.,Ltd.: Undertake the research and study of the products and the prepare for the construction of the land-based testing platform, and provide all requisite conditions for completion the test project;
3. Marine Material Science and Engineering Institute of Shanghai Maritime University: undertake working out the testing program, and undertake the site organization and allocation of the project.

All testing processes shall be conducted in the presence of China maritime authorities or ship surveyor appointed by it from China Classification Society.

This *Quality Assurance Project Plan* is mainly worked out for land-based testing of HY^{TM}-BWMS products as per the guide rules given in G8, and the *Quality Assurance Project Plan* intended for ship-based test will be submitted separately.

This land-based test is finished jointly by personnel from 3 units, and the composition of personnel is given below:

As the research, development and production unit, Shanghai Hengyuan Marine Equipment Co.,Ltd. dispatches 15 employees to participate in the test, and they main undertake the rear supply and guarantee including manipulation and operation of in-situ test equipment, electric power, installation and purging.

Shanghai Maritime University mainly undertake working out the test program, control the test progress/flow, and assist the testing unit to take samples in process of the test.

The First Institute of Oceanography, SOA undertakes the testing task of the test, and undertakes the on-site sampling and analysis of sample parameters.

2.1.1 Shanghai Hengyuan Marine Equipment Co.,Ltd.

Project director: Xia Liang

No.	Name	Educational background	Specialty	Job title	Responsibility for the project
1	Zou Maoxia	Undergraduate	Fluid engineering	Deputy general	Project director

				manager	
2	Xia Liang	Undergraduate	Electrical engineering	Engineer	Autocontrol
3	Wu Bin	Undergraduate	Mechanical engineering	Engineer	Mechanical design
4	Li Guixin	Undergraduate	Mechanical engineering	Engineer	Mechanical design
5	Wang Yonghua	College graduate	Quality manager	Engineer	Quality manager
6	Ma Quansheng	College graduate	Mechanical engineering	Engineer	Quality manager

2.1.2 The First Institute of Oceanography, SOA

Project director: Li Ruixiang (researcher).

No.	Name	Age	Educational background	Specialty	Post/Job title	Responsibility for the project
1	Li Ruixiang	56	Undergraduate	Marine organism	Researcher	Group leader
2	Li Yan	33	Master	Marine organism	Research assistant	Phytoplankton
3	Sun Ping	29	Master	Marine organism	Research assistant	Phytoplankton
4	Zhang Jinxing	56	Undergraduate	Marine organism	Researcher	Microorganism
5	Wang Baodong	46	PhD graduate	Marine chemistry	Researcher	Chemistry
6	Xie Linping	29	Master	Marine chemistry	Research assistant	Chemistry
7	Qu Lingyun	35	PhD graduate	Marine organism	Associate research fellow	Microorganism
8	Liu Ping	29	Undergraduate	Marine organism	Research apprentice	Zooplankton

2.1.3 Shanghai Maritime University

Project director: Yin Yansheng (professor);

No.	Name	Age	Educational background	Specialty	Post/Job title	Responsibility for the project	Certificate for qualification
1	Yin Yansheng	56	PhD graduate	Marine materials	Researcher	Group leader	See the quality assurance program
2	Dong Lihua	47	PhD graduate	Marine materials	Researcher	Deputy group leader	See the quality assurance program
3	Zhang Li	37	PhD graduate	Environmental material	Researcher	Chemistry	See the quality assurance program
4	Zhou Yun	29	Master	Marine chemistry	Researcher	Chemistry	See the quality assurance program
5	Liu Tao	30	PhD graduate	Marine chemistry	Researcher	Microorganism	See the quality

							assurance program
6	Chang Xueting	28	PhD graduate	Marine chemistry	Researcher	Phytoplankton	See the quality assurance program
7	Guo Na	28	Master	Marine organism	Researcher	Zooplankton	See the quality assurance program
8	Wang Dongsheng	29	Master	Electromechanical	Engineer	Systems operation	See the quality assurance program
9	Fan Chunhua	36	Master	Electromechanical	Engineer	Systems operation	See the quality assurance program
10	Dong Yaohua	28	PhD graduate	Electromechanical	Engineer	Systems operation	See the quality assurance program
11	Zhang Huiyan	33	PhD graduate	Electromechanical	Engineer	Systems operation	See the quality assurance program

3. Description of the independent laboratory and all test facilities and subcontractors

Qualification of the testing organization and testing method for the project

See *QAPP of HY-BWMS* and *IP and QC of HY-BWMS*

4. Brief Introduction to the Hengyuan Ballast Water Management System

4.1 Introduction to the Hengyuan ballast water management system (HYTM-BWMS)

As per the guide rule G8 (Guide to approval of ballast water management system) and guide rule G9 (approval procedure for ballast water managerial system using active substances) given in the international convention on ballast water management, Shanghai Hengyuan Marine Equipment Co.,Ltd. applies for type approval for "Hengyuan ballast water management systems (HY^{TM}-BWMS)" manufactured by it. All contents given in this report conform to the GESAMP-BWWG information collection and working methods.

Shanghai Hengyuan Marine Equipment Co.,Ltd. has developed a set of ballast water treatment system (HY^{TM}-BWMS) based on medium-pressure ultraviolet radiation (MPUV) sterilization technology, which features its building block design and may be nimbly configured as per the requirements for ballast water treatment capacity of ship tonnage. The system is working as per two-stage processing techniques; in other words, ballast water may be subjected to filtration treatment once at the water inlet, and may be subjected to ultraviolet treatment once more before it flows out of the water outlet. In this way, the system may eliminate the possibility to discharge any organism that may revive or revegetate from the ballast cabin into the ocean.

Hengyuan ballast water management systems (HY^{TM}-BWMS) is mainly composed of 3 core units, namely filtration unit, ultraviolet radiation reactor unit and autocontrol unit. Of which, the filtration unit is located before the reactor unit and is used to remove inclusions such as particles from the seawater, and remove part of the marine phytoplankton, zooplankton and microorganism etc. The filtering system is provided with self-purging function, and its operation and purging may not affect the entire treating processes of ballast water, and the post-filtration total dirt retained may be directly discharged into the ballast-gathering sea area such that the total dirt retained may not be carried over to a next destination of voyage.

4.2 Description of ballast water management system HYTM-BWMS

4.2.1 Operating principle of the system

The HY^{TM}-BWMS system adopts a processing method composed of prefiltering ＋ medium-pressure ultraviolet treatment microorganism, its specific operational process is conducted by a control system, and a block diagram of operating principle of the system is given in Fig. 1.1:

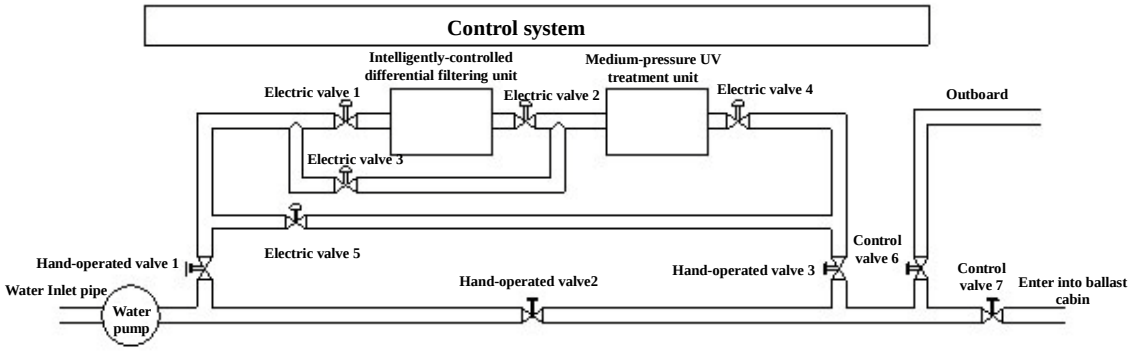


Fig. 1.1 Operating Principle of HY^{TM}-BWMS System

When ballast water is load, the seawater passes through a self-purging filter and ultraviolet treatment unit. The back flushing filth may be discharged in-situ into the seawater ballasting area, such that the other sea area may not

be subjected to adventive invasion and contamination. The filtered ballast water is subjected to ultraviolet treatment to kill the microorganism. When ballast water is unloaded, the water inside the ballast cabin is not directed to pass through the filter because it had been filtered when ballasting; however, it may be optionally subjected to ultraviolet treatment so as to prevent the microorganism inside the inside-cabin ballast water from reviving.

The ballast seawater pretreatment conducted by filtration unit may not only prevent bigger organic substances or organism from being carried into the ballast cabin along with the ballast water, but also considerably reduce the content of particles in the filtered and pretreated ballast water, so as to correspondingly reduce the deposited matter inside the ballast cabin and greatly suppress the stemming of microorganism inside the ballast-cabin deposited matter in process of voyage of the ship.

When the filtered ballast water passes through the ultraviolet treatment unit, C-band ultraviolet beats down on the liquid and destroy the DNA and RNA inside the cell tissue of microorganism like bacteria and virus in a flash. The virus or bacteria exposed to that wave band may take in a dose of 6000 ~10000U.W. sec/cm^2 or more, the DNA (deoxyribonucleic acid) inside their vital center goes to rack and ruin such that they die or lose reproductive capacity immediately. Ultraviolet rays fall within broad-spectrum sterilization technology, and it may kill almost any microorganisms, including bacteria, tubercle bacillus, virus, gonite, fungi and algae etc.

With the aid of treatment conducted by ballast water system HY^{TM}-BWMS, the discharged ballast water may meet the standard specified in the IMO resolution for ballast water. The major components and performance of HY^{TM}-BWMS ballast water system are given as follows:

System composition: auto intelligent-control pressure-difference filtration unit, medium-pressure ultraviolet treatment unit, solenoid valve and connecting line, control system and several testing sensing probes

Treatment capacity: 150~ 1600m^3/h, optional

Supply voltage: AC380, 3-phase

Filtration fineness: 40μm

UV dosage: 200 mJ/cm^2-300mJ/cm^2

Design pressure:16kg/cm^2

Operating pressure:1.5~10kg/cm^2

4.2.2 Product specification of ballast pumping system HYTM-BWMS

With its modularized packaged design, HY^{TM}-BWMS is applicable to treatment of ballast water with a flow rate ranging from 150m^3/h to 1600m^3/h. The basic unit treatment capacity of the system is 200m^3/h. The fail safe system allows flexible configuration, and is highly suitable to install and work on built or newly-built ships. The product specification and series of HY^{TM} –BWMS ballast pumping system are listed in Table 4.1:

Table 4.1 Performance Parameters of Basic Units of Ship's Ballast Water Treating Plant HY^{TM}-BWMS-200

Parameters of basic units of HY^{TM}-BWMS -200	
Model	**HY^{TM}-BWMS- 200**
Rated treatment capacity (m^3/hr)	**200 m^3/h**
Power range/ average (KW)	**18-26/20KW**

Inlet-outlet pressure difference (MPa)	**0.05MPa**
Pressure-proof pressure (MPa)	**1.0MPa**
Filtration fineness (um)	**40um**
Overall size (m)	**2.58X1.05X2.23 (2.7)**
Weight (Kg)	**1750**

Based on the specs and models of above-mentioned major components (including intelligent control pressure difference filtration unit and ultraviolet treatment unit), HY^{TM}-BWMS ballast water management system may allow different combination of its major component to meet the clients' requirements for ballast pumping system. The specific product serials are listed in Table 4.2.

Table 4.2 Product serials of HY^{TM}-BWMS Ballast Water Management System

Product serial Number	Treatment Capacity m3/hr	Power (KW)	Overall size (m) (LXWXH) and area (m^2)	Weight (kg)	Remarks
HY^{TM}-BWMS- 150	150	12-18/14KW	2.58X1.05X2.23(2.7)	1750	Basic unit (substitute)
HY^{TM}-BWMS- 200	200	18-26/20KW	2.58X1.05X2.23(2.7)	1750	Basic unit
HY^{TM}-BWMS-400	400	36-48/42KW	2.6X1.05X2.71(2.73)	2100	Two sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-600	600	60-72/62KW	2.6X1.05X2.71(7.23)	2100	Three sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-800	800	72-96/74KW	2.6X2.78X2.71(7.23)	3400	Four sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1000	1000	96-120/96KW	2.6X2.78X2.71(7.23)	3400	Five sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1200	1200	96-120/102KW	2.6X2.78X2.71(7.23)	3400	Six sets of **basic unit combination of HY^{TM}-BWMS- 200**
HY^{TM}-BWMS-1400	1400	126-168/132KW	2.8X4.4X2.71(12.32)	4800	Seven sets of **basic unit combination of HY^{TM}-BWMS- 200**

HY^{TM}-BWMS-1600	1600	144-192/150KW	2.8X4.4X2.71(12.32)	4800	Eight sets of **basic unit combination of HY^{TM}-BWMS- 200**

Fig. 4.2 shows a photo of overall construction of treatment device intended for land-based test of HY^{TM}-BWMS -200 basic units to be conducted in future, of which the treatment capacity is 200m^3/h.

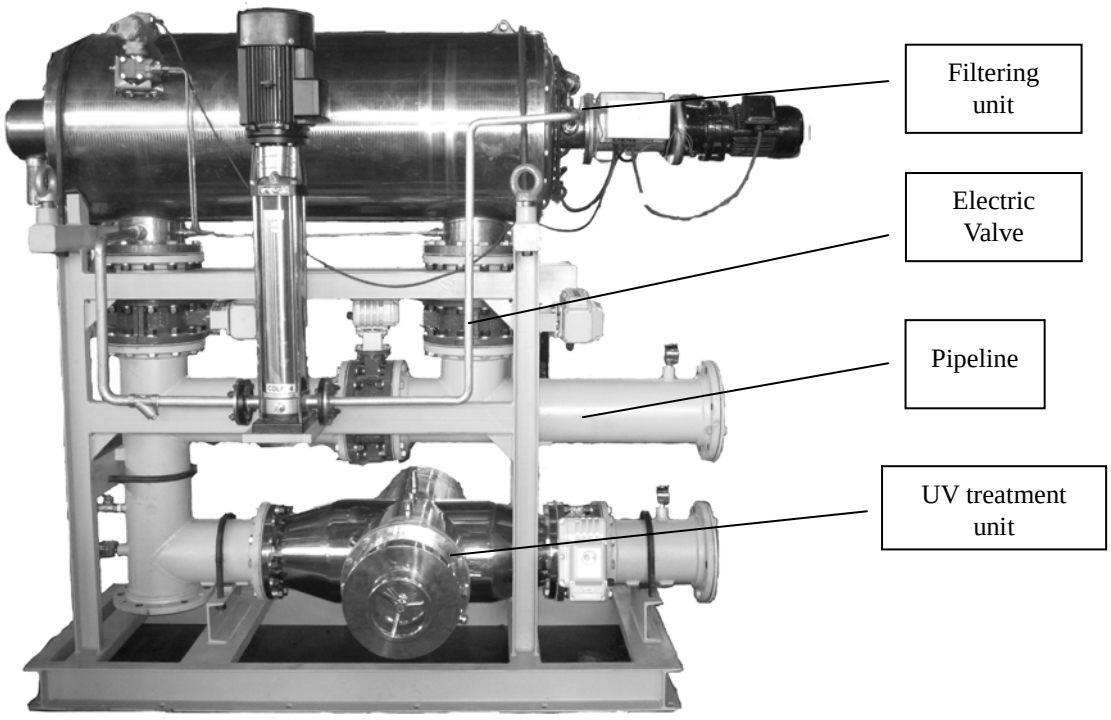


Fig. 4.2 General Assembly Drawing of HY^{TM}-BWMS-200 Ballast Water Management System

The working flow of the system is shown in Fig. 4.3a and Fig. 4.3b.

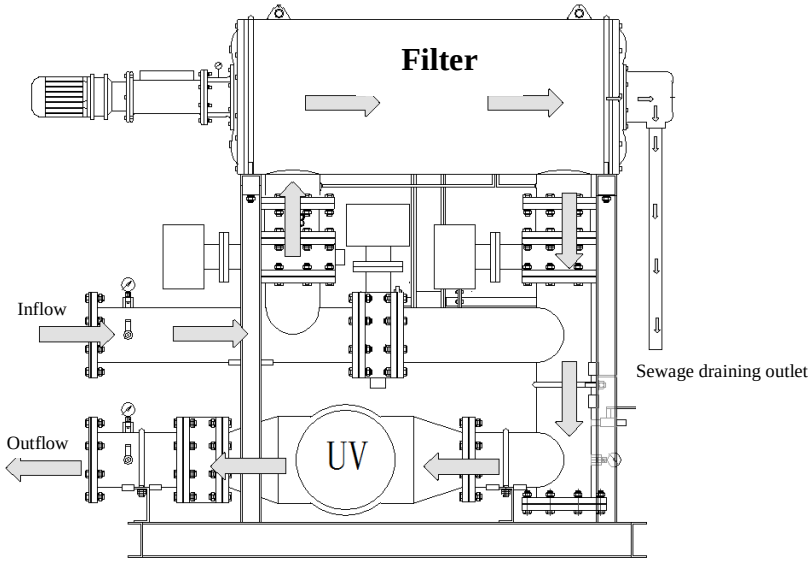


Fig. 4.3a Flow Chart of Ballasting of HY^{TM}-BWMS-200 System

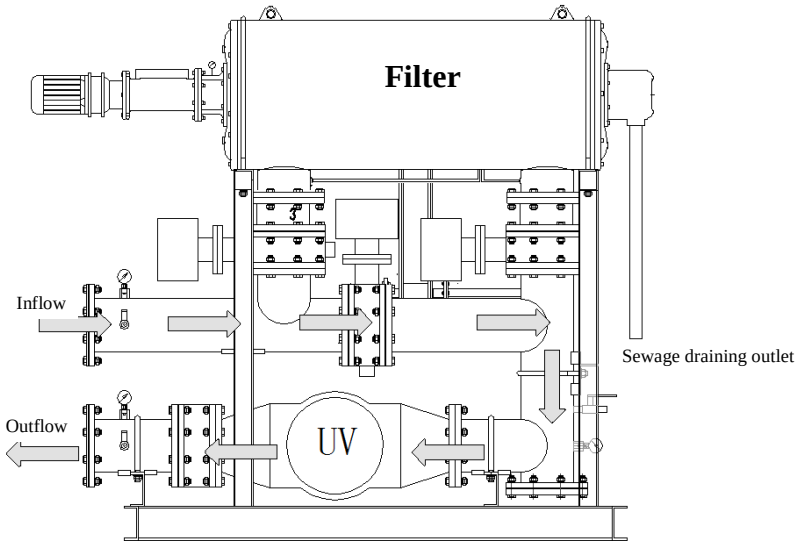


Fig. 4.3b Flow Chart of Unloading of HY^{TM}-BWMS-200 System

4.2.3 Intelligent-control pressure-difference filtration unit

HY^{TM}-BWMS ballast pumping system is equipped with an intelligent-control pressure-difference filtration unit furnished with high-strength screen mesh and filtering element, and the perfect filtration and pretreatment functions are capable of high-pressure backwash, automatic blowing down, full automatic manipulation of operational process, and blowing down without setting-off.

In contrast with other similar filtering equipment, the intelligent-control pressure-difference filtration unit is provided with the following characteristics:

- The intelligent-control pressure-difference filtration unit is equipped with a 40-micron high-strength sintered mesh. It may carry out backwash up to a high pressure of 2.0Mpa to thoroughly clean the strainer mesh at high efficiency to fully recover it to its initial state so as to achieve lifetime service without replacement.

- The filter separator is capable of automatic indexing, automated implementation of high pressure back flushing as per the various retrieved data, and unattended operation regardless of unstable fluctuation of water quality without manual intervention.
- The control system features rapid response and accurate operation, and it may regulate the backwash pressure-difference as per different water sources;
- Capable of back flushing without interruption of normal water producing, ensuring continuous, steady and reliable operation.
- Short duration of back flushing, such that the backwash water consumption is restricted to only 0.001 ~ 0.002% of normal water yield, ensuring water conservation, power conservation and energy conservation.
- Compact and reasonable structural design, with less wearing parts, without consumables, with low operation and maintenance costs, ensuring easy operation, management, installation and relocation.

Its contour and internal structure are shown in Fig. 4.4

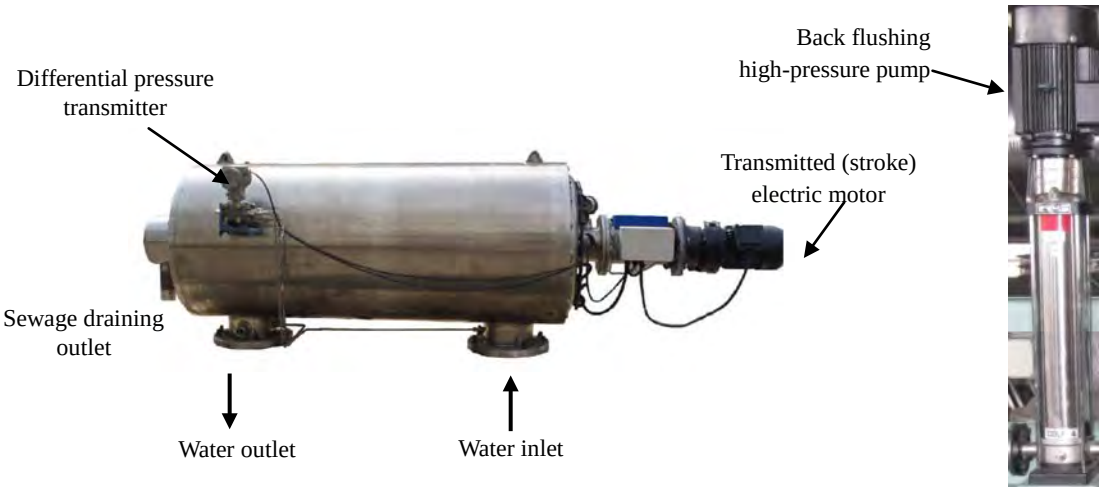


Fig. 4.4 Major Component of Automatic Intelligent-control Pressure-difference Filtration Unit

Specific technical parameters of operation are listed in Tables 4.4 and 4.5:

Table 4.4 Technical Parameters of Operation

Filtration fineness	40um
Unit-set underground-water testing flow-rate (rated)	200m^3/h
Minimum operating pressure	0.15MPa
Maximum operating pressure	1.0MPa
Pressure loss	0.01～0.05MPa
Temperature of filtering medium	0～70℃
Normal output (ultrasonic)	1.44 kw

Technical parameters of purging

Table 4.5 Technical Parameters of Purging

Back flushing pressure	2.0MPa (varying depending on operating pressure)
Duration of back flushing	60 seconds
Water consumption for back flushing	120~160 L (varying depending on operating pressure)
Power consumption for back flushing	0.085kw/time

4.2.4 Ultraviolet (UV-C) treatment unit

The ultraviolet light treatment unit can effectively kill the halonereid, phytoplankton, heterotrophic bacteria, pathogenic bacteria and virus.

The contour of ultraviolet (UV -C) module is shown in Fig. 4.5.

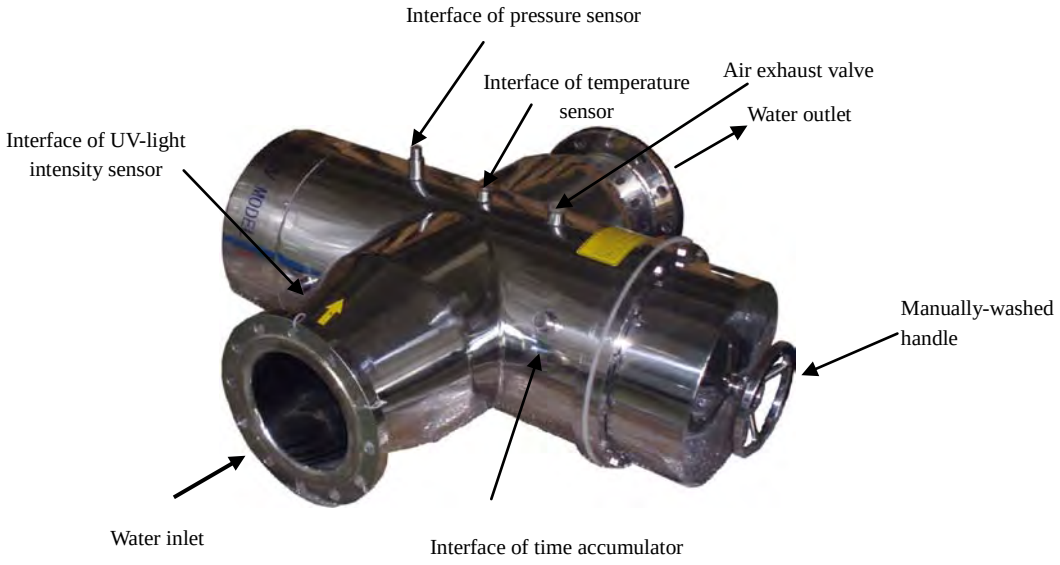


Fig. 4.5 Appearance View of Ultraviolet Treatment Unit

The ultraviolet treatment unit is mainly composed of the following several sections: strip lamp, jacket pipe, amperite, power supply, stainless-steel reaction device, accumulative time demonstrator, ultraviolet intensity monitor and manual purging arrangement. The ultraviolet treatment unit is provided with the following advantages:

- Allowing series or parallel connection as per different treatment capacity required for the application
- Capable of completely killing any residual heterotrophic bacteria and organism after stage-1 and stage-2 filtration.
- Free of toxicity residue
- Highly significant sterilization effect
- Easy maintenance and operation

4.2.5 Control and monitoring device

The control box of ultraviolet treatment unit is shown in Fig. 4.6:

Fig. 4.6 Control Cabinet of Ultraviolet Treatment Unit

The electric control cabinet is cooled by a fan so as to ensure the heat elimination of capacitors and UV -C supply transformer. The section is intended to provide working power supply and control source for the ultraviolet lamp.

The control and monitoring system may monitor the systems operation and feed power supply to the components. HY^{TM}-BWMS is provided with multiple monitoring points used to measure and self-regulate the parameters such as pressure, flow rate, temperature, turbidity and ultraviolet exposure dosage. The data acquired from these measuring points may be transmitted to the control center of the system (Fig. 4.7) for managing and controlling the self-adjusting parameters of supply unit and valves in order to ensure true running of the system.

Fig. 4.7 Main Interface of Touch Screen of Control and Monitoring Device

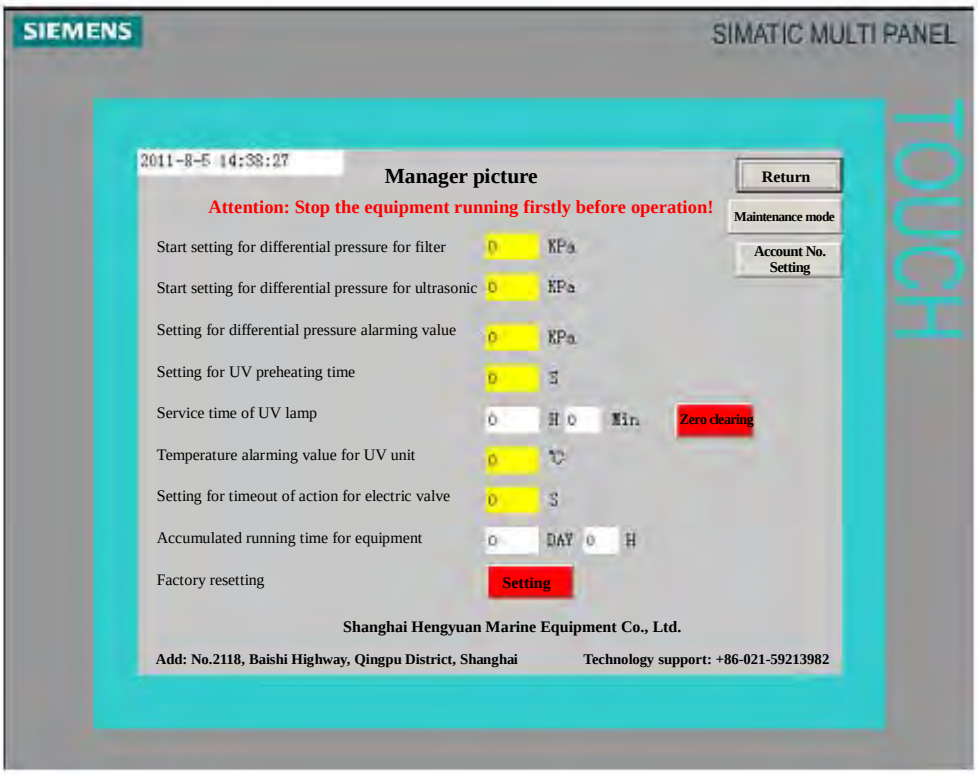


Fig. 4.8 Administrator Parameter Setting Interface

The control device of HY^{TM}-BWMS may automatically and constantly monitor and adjust all parameters required for UV-C module during operation. In case an exception occurs in the working parameters of UV-C, audible and visual alarm information may be output, and the position and fault category of the exception may be indicated. During the ballasting and unloading, the UV module may be automatically regulated as per the signals output by the UV -C intensity sensing probes built in the system, so as to ensure that the efficacious exposure dose must not be exceeded.

5. Design of Land-based Test Program

5.1 Land-based test site

Land-based test is to be conducted at the National Oceanographic Center, Qingdao namely the Life Science and Technology Teaching and Research Base of China Ocean University, as shown in Fig. 5.1.

Fig. 5.1 Life Science and Technology Teaching and Research Base of China Ocean University

The Life Science and Technology Teaching and Research Base of China Ocean University is located to the south of Aoshanwei Township, Jimo, Qingdao, and to the west of sea, adjacently to the Binhai Avenue, ensuring easy access. Main facilities include: a scientific research building of 5700 square meters in floor area, in which the function laboratories and an open public laboratory falling with the research fields i.e. aquaculture and bionomy, animal nutrition and immunity, marine biological technique, and genetic breeding, and 26 sets of closed-cycle experimental systems are established therein. Production shops of up to 9340 square meters have been built up in the base, mainly including an aquatic-livestock raising seedling and aquaculture workshops, and a feedstuff cultivation workshops.Of which, the feedstuff cultivation workshop is equipped with 2 sets of 5T photobioreactors and 400 sets of 60-cm unicellular-algae cultivation columns, and it may provide all microorganisms in quantities required for the land-based test (as shown in Fig. 5.2).

Fig. 5.2 Unicellular-algae Cultivation Columns in the Feedstuff Cultivation Workshop

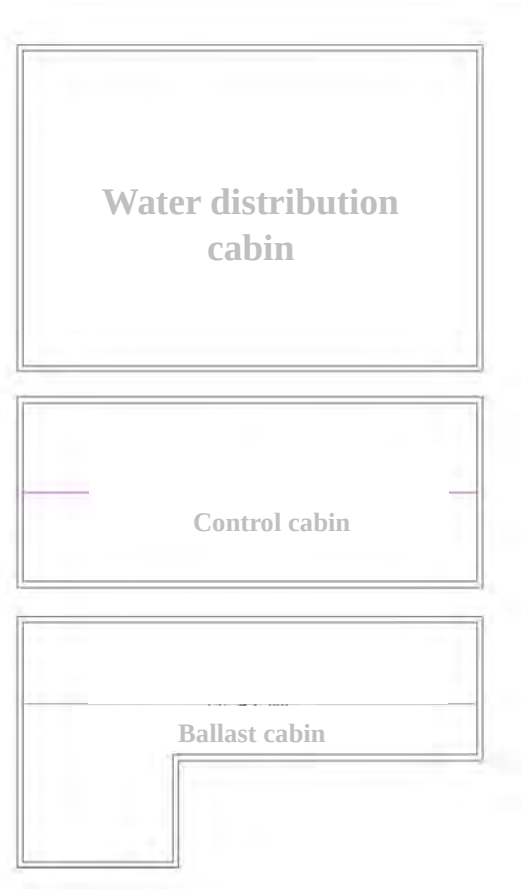
5.2 Arrangement of test cabins

As per the requirements of G8 guide rules, the entire land-based test is divided into 2 groups of test cycles as per different raw-water salinity (5 identical salinity is regarded as 1 group, high salinity higher than 32PSU is regarded as 1 group, low Salinity ranging 3 to 32 PSU is regarded as 1 group). The test arrangement is given below as per the conditions of the testing site:

Table 2.1 Types and Capacities of Testing Cabins

No.	Name of cabin	Capacity
NO.1	Water distribution cabin	**≈1170 m^3**
NO.2	Control cabin 1	≈**2**20 m^3
NO.3	Control cabin 2	≈**2**20 m^3
NO.4	Ballast cabin 1	≈260 m^3
NO.5	Ballast cabin 2	≈260 m^3

The layout of the land-based test base is shown in the figure below:

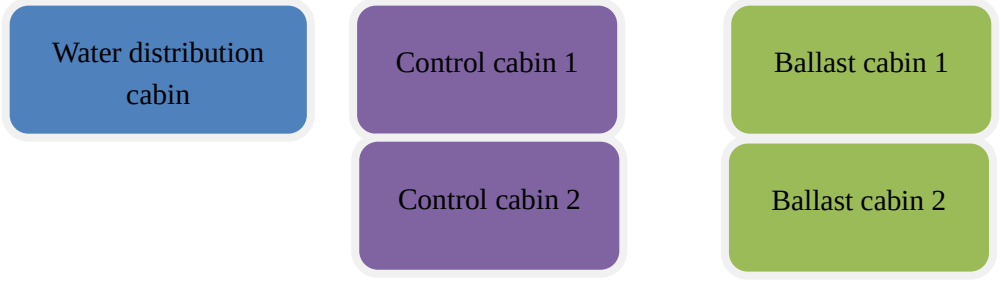


Layout of the land-based test base

The water distribution cabin is used to blend and store influent water for the test in each test cycle, the control cabin is used to store the matched water for each test, and the ballast cabin is used to store the treated water during each test. Each simulation cabin is equipped with its respective water intake and drainage network, and seawater may be interchanged between the simulation cabins by opening/closing the valves and pumps. The Ballast simulation cabin may be enclosed to prevent solar radiation during the test. All pipe networks and valves irrespective of the test are kept in their locking positions with clear indication. Once the cabin is put into service, they shall be locked up immediately and affixed with the sealing tapes witnessed by the attending surveyor, which shall be maintained till the test is over.

During the test, once the cabins are purged thoroughly, the in-situ witnessing ship surveyor shall confirm that the ballast cabin is sealed, and affix a lead seal for keeping. When the test is over, the lead seal shall be removed by the in-situ witnessing ship surveyor.

To avoid the confusion of positions and names of the simulation cabins, a data plate shall be affixed onto the upside of each simulation cabin to indicate the purposes and numbers of the cabins. The data plate is shown in the figure below.



Before each set of testing procedure is started and between test cycles, the test apparatus (all simulation cabins and piping lines intended for the test) shall be purged with fresh water, the cabins shall be wiped with clean cloth till they are rated as clean by eyeballing, the debris, organic substances and other inclusion shall be removed, and drying process shall be conducted finally.

If the influent water conforms to the indices of physical chemical properties specified by G8 guide rules, no additive substances shall be added into the water storage cabin. If it fails to meet the indices specified in G8 guide rules, sea salt, fresh water or marine organism shall be respectively added into the feedwater cabin to enable them to reach the indices before the test is conducted. The compliance of influent water shall be witnessed and recorded by the attending surveyor (salinity and microbe density).

The operating process of test is briefly described in the following:

Test the salinity and microbe density of seawater first. If the salinity is too high, prepare for adjusting downwards the salinity; otherwise prepare for adjusting upwards the salinity. Pump crude seawater into the water distribution cabin, and configure the seawater as per the testing result so as to fulfill the test requirements.

When the crude water is prepared, use a ballast pump to pump the crude water into the treater for simulated ballast cabin treatment. Allow the treated water to flow into the simulation ballast cabin, and use a water-distribution pump to pump the matched water into the control cabin simultaneously. When a stationary phase of 5 days for the water inside ballast cabin expires, pump the water from the treatment cabin back into the treater to simulate the unloading process.

5.3 Sample points for the test process

The process flow and sample points for ballasting are shown in Fig.5.4.

It is observed from the figure that the fresh water, microorganism and seawater are adequately blended by a mixing plant before the mixture is fed into the water distribution cabin. At this point, use a water sampler to take $1m^3$ of water sample at point A to verify whether the blended water reaches the G8 standard.

When ballasting is conducted, part of the blended influent water is fed by ballast pump from the water distribution cabin through the cushion tank and Y-shaped filter into the HY^{TM}-BWMS ballast water management system for treatment before it is fed into the ballast cabin for 5-day storage; other part of the blended influent water is not treated by the HY^{TM}-BWMS ballast water management system, and it is directly fed into the control cabin for 5-day storage.

In process of ballasting, use an inside-pipe water sampler to collect influent water sample at point B, and use an inside-pipe water sampler to collect ballast treated water sample at point C.

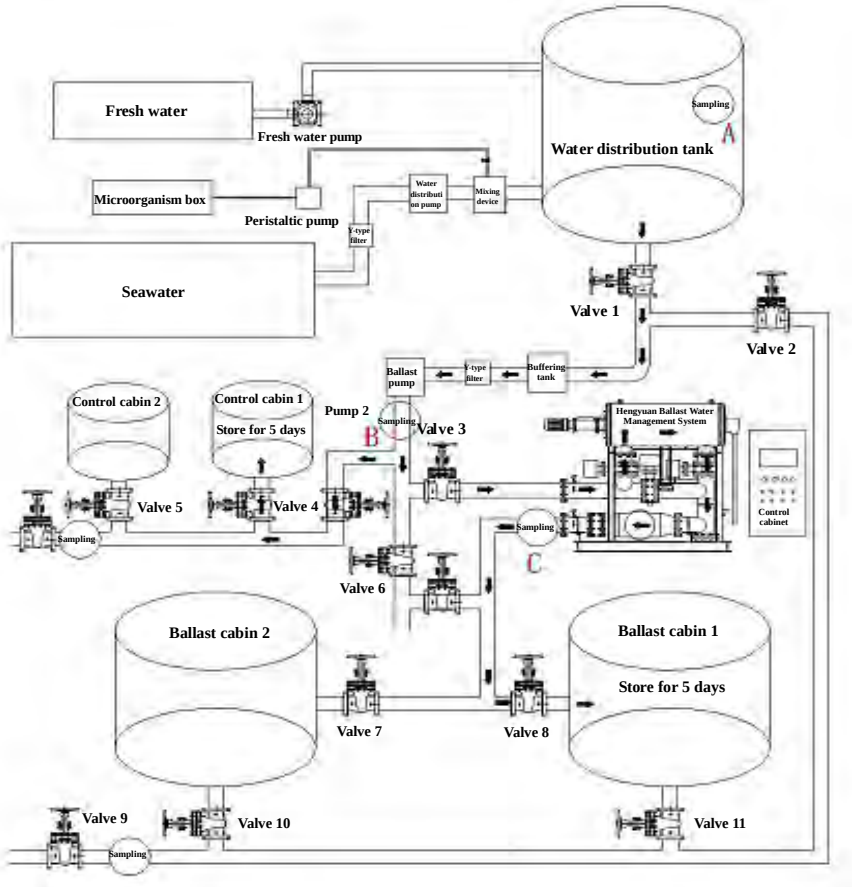


Fig.5.4 Process Flow and Sample Points for Ballasting

Point A is intended for sampling by water sampler, and points B and C are intended for inside-pipe sampling.

The process flow and sample points for unloading are shown in Fig.5.5.

It is observed from the figure that for discharge occurring once the 5-day storage expires, water from ballast cabin is once more pumped by ballast pump into the HY^{TM}-BWMS ballast water management system for treatment before it is directly discharged into the sea; While the water from the matched is not treated by the HY^{TM}-BWMS ballast water management system before it is directly discharged into the sea.

In process of unloading, use an inside-pipe water sampler to collect pre-unloading discharge water sample at point D, use an inside-pipe water sampler to collect post-unloading discharge water sample at point E, and use an inside-pipe water sampler to collect sample of water discharged from the control cabin at point F.

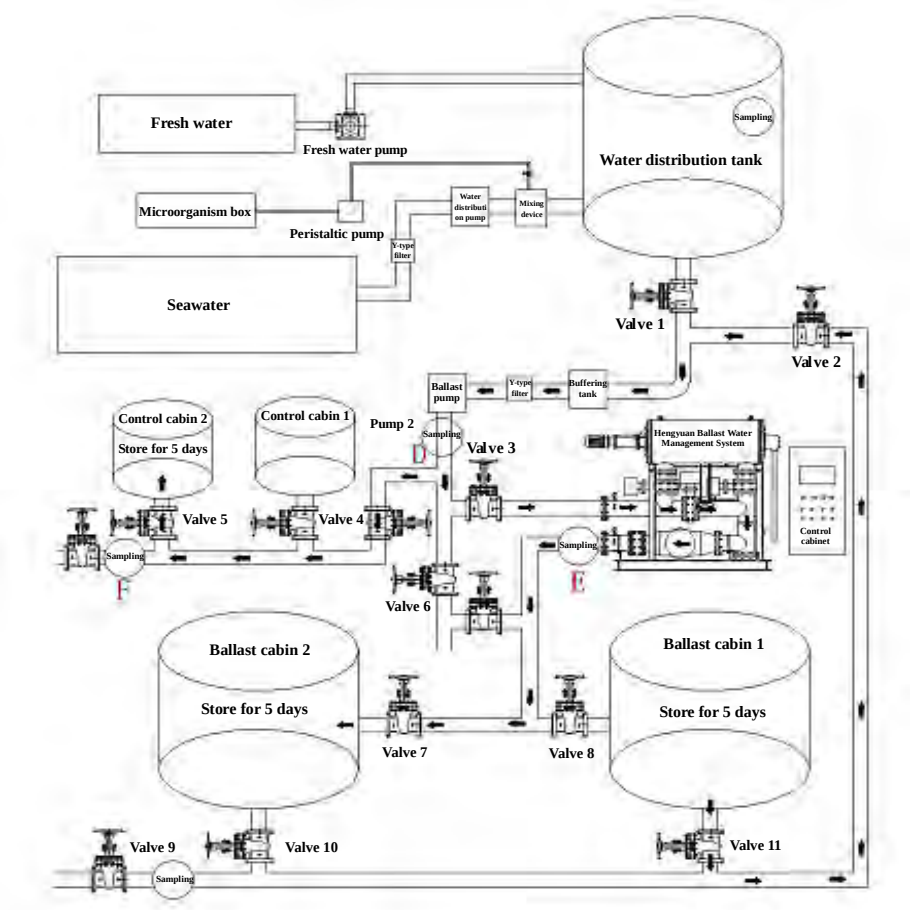


Fig. 5.5 Process Flow and Sample Points for Unloading

Sampling conducted at points D, E and F fall within inside-pipe sampling.

5.4 Sampling equipment

As shown in Fig. 5.4 and 5.5, the entire HY^{TM}-BWMS ballast water management systems is equipped with 6 sample points, namely A, B, C, D, E and F. A water sampler is adopted for point A. Prior to each test, water sample shall be taken from the water distribution cabin for analysis to confirm that the influent water intended for test conforms to the requirements of G8.

Inside-pipe sampling device is intended for points B, C, D, E and F (as shown in Fig. 5.6), which is designed as per the sampling specifications(Article 4.7, Chapter 1, Part 3, Subject 2 of California Rules), and the port diameter is determined as per the following equation: $\mathrm{Diso} = Dm\sqrt{\frac{Qiso}{Qm}}$

Here, Diso and Dm indicate respectively the aperture of sampling port and the inner diameter of sampled pipe; Qiso and Qm indicate respectively the velocity of flow when water pass through the 2 pipes.

The results of calculation show that it takes approximately 3 minutes to take 1m^3 of water sample when the port diameter of sampling device is 63mm, sampling flow rate is 20.2m^3/hr, and velocity of flow is 1.8m/s.

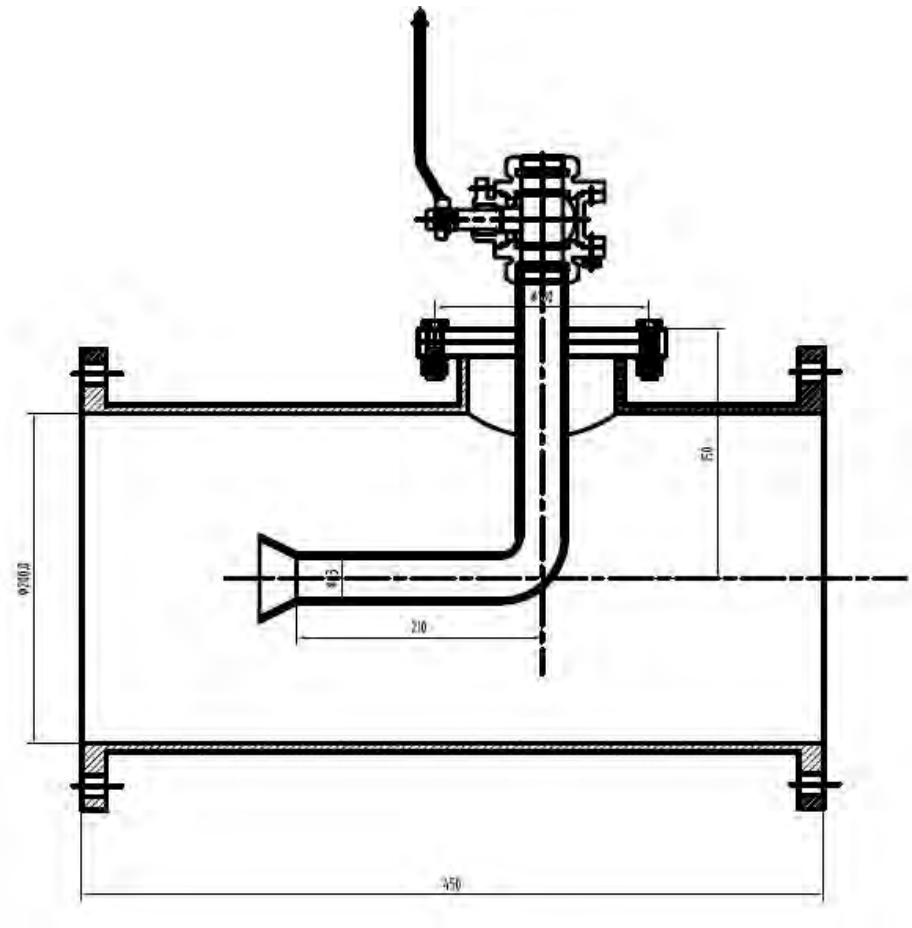


Fig. 5.6 Inside-pipe Sampling Device

5.5 Testing parameters

HY^{TM}-BWMS ballast water management system may test the following parameters:

(1) Organism: ≥50μm and 10~50μm;

(2) Microorganism: escherichia coli, vibrio cholerae and heterotrophic bacteria;

(3) Water quality: pH value, temperature, salinity, dissolved oxygen, TSS, DOC, POC and NTU

5.6 Treatment capacity of test apparatus

Treatment capacity: 200±10 m^3/h

Treatment: double treatment to be conducted when ballasting and unloading (not through the filter when unloading)

Power consumption: HY^{TM}-BWMS＞17.5kw

Cubic measure of treated water: Greater than 220m^3 (each test cabin)

5.7 Commissioning and trial run of the equipment

When the installation and commissioning of HY^{TM}-BWMS ballast water management systems are finished, use seawater to allow it to continuously operate for at least 24 hours on the land-based testing platform so as to verify the safe reliability of the entire HY^{TM}-BWMS ballast water management systems and its valves, pumps and pipelines.

Before the land-based test is formally started, a one-cycle trial run shall be conducted as per the operational process of the system so as to confirm the normal operation of the overall system; in addition, drilling of sampling and manning levels may also be performed so as to guarantee that the land-based test may be normally conducted.

5.8 Preparation prior to the land-based test

5.8.1 Preparation of seawater

Crude seawater for the test may be taken from the sea area of Yellow Sea in Jimo, Qingdao, and water pumps with throughput rate of 486m^3/hr may be used to pump seawater into the water distribution cabin.

Totaling 2 groups of land-based test shall be conducted (high salinity group＞ 32 PSU, low Salinity group≤22 PSU), and 5 test cycles shall be finished for each group. Two (2) cycles shall be finished for the test of one group; therefore, seawater enough for 2 test cycles shall be prepared at a time, and the gross amount shall not be less than 1170m^3.

5.8.2Preparation of fresh water

To conduct a low-salinity (salinity≤22PSU) test cycle, fresh water must be added into seawater. Fresh water for this test is underground brine water taken from Aoshanwei, Jimo, which falls within crude brackish water (salinity ≈5PSU).

If the salinity of seawater taken for the test is 30PSU, in order to blend 1170m^3 of testing water with salinity ≤22PSU for the water distribution cabin, then,

The amount of seawater desired is $30\ x+(1170-x)\times5=1170\times22$; $x=702$m^3

The amount of fresh water desired is $1170-x=1170-702=468$m^3

The result determined with the above equation shows that at most 702m^3 of seawater and at least 468m^3 of fresh water are required for blending 1170m^3 of testing water with salinity≤22PSU (under identical temperature conditions).

5.8.3 Preparation of sea salt

To conduct a high salinity (salinity＞32 PSU) test cycle, if the salinity of sea water in the said sea area is ≤32PSU, sea salt must be added into the seawater such that the salinity of influent water intended for the test may cut the mustard. For this test, the sea salt to be added in shall be local crude salt.

If the salinity of seawater taken for the test is 30PSU, in order to blend 1170m^3 of testing water with salinity＞ 32PSU for the water distribution cabin, then,

The amount of sea salt to be added in is $1170\times30+x=1170\times32$; $x=2.34$t$=2340$ kg

The result determined with the above equation shows that at least 2340kg of sea salt shall be added in for blending 1170m^3 of testing water with salinity ＞32 PSU (under identical temperature conditions).

5.8.4 Preparation of marine organism

The marine organism to be added in for the land-based test shall be cultivated by The First Institute of Oceanography, SOA as required. When the cultivated biological inoculum is added into the water intended for the test, it is required to air-inflate the water body by air pumps through aerating apparatus such that the microorganism may be evenly distributed inside the water intended for the test.

The result of organism density inspection prior to the test shows that the organism density of 50μm is too low, and the breeding base of China Ocean University is already consigned to cultivate rotifer.

The organism density of 10-50 μm in both outdoor water storage tank and indoor tanks exceeds the density and species required for the water intended for test so as to guarantee the enough organism density in the entire test process. In addition, green algae and yellow-green algae etc. are also cultivated in the breeding base of China Ocean University.

5.9 Detailed test plan

5.9.1 Test progress arrangement

The test plan on continental rise is officially begun on October 21, 2011, and there are 2 test groups with 10 test cycles in total, each test cycle lasts for 6 days. The table below shows the specific time arrangement for test cycle in month-day.

Test cycle	Test group	Test time	Water distribution time	Test TRO time	Sampling time for ballast	Sampling time for unloading
1	Salinity ≤22 PSU	10-21～10-26	10-20	10-21,10-26	10-21	10-26
2	Salinity ≤22 PSU	10-21～10-26	10-20	10-21,10-26	10-21	10-26
3	Salinity ≤22 PSU	10-27～11-01	10-26	10-27,11-01	10-27	11-01
4	Salinity ≤22 PSU	10-27～11-01	10-26	10-27,11-01	10-27	11-01
5	Salinity ≤22 PSU	11-02～11-07	11-01	11-02,11-07	11-02	11-07
6	Salinity ＞32 PSU	11-2～11-07	11-01	11-02,11-07	11-02	11-07
7	Salinity ＞32 PSU	11-08～11-13	11-07	11-08,11-13	11-08	11-13
8	Salinity ＞32 PSU	11-08～11-13	11-07	11-08,11-13	11-08	11-13
9	Salinity ＞32 PSU	11-14～11-19	11-13	11-14,11-19	11-14	11-19
10	Salinity ＞32 PSU	11-14～11-19	11-13	11-14,11-19	11-14	11-19

5.9.2 Test operation procedure

As shown in the following table, each test cycle lasts for 6 days, and the test contents and numbers on each day are as shown in the following table.

Preparation	Ballast	1	2	3	4	5 (Unloading)

D-1	D0	D1	D2	D3	D4	D5

The following table is the specific operating procedure of each test cycle:

Time	No.	Operation of specific operating content
D-1 Preparation	1	Prepare the seawater, fresh water and sea salt for raw water allocation, 1170t seawater, 468t fresh water and 2.34t sea salt should be guaranteed respectively at least. Specific procedures of water allocation refer to preparatory work prior to test on continental rise in 4.2 of this text. In addition, minimum 300t disinfected fresh water is required to provide for cleaning the test cabin and pipeline.
	2	Hydrophore shall be used for sampling in water water distribution cabin to inspect whether the raw water conforms to G8 requirements, including testing of biological, chemical and physical performance (POC, DOC, TSS, decomposition oxygen, PH value, salinity, temperature and turbidity).
	4	Inspect whether the equipment for management system of HY^{TM}-BWMS ballast water run stably or not. Stable system operation means that pressure, flow and UV irradiation intensity inside the system pipe have reached to rated value under rated current, voltage and power dissipation, similarly hereinafter.
	5	Inspect whether sampling equipment are accurate, including PE barrel and filtering screen, etc.
	6	Inspect whether the electric power and pipeline, etc are well prepared.

D0 Ballast 1	1	Provide the water water distribution cabin: Pour 1170t inflow water into water water distribution cabin in accordance with G8 requirement.
	2	Start the test for first-cycle ballast treatment: partial inflow water flows into ballast cabin 1 after HY^{TM}-BWMS treatment in water allocation tank; The other part of inflow water flows into control cabin 1 directly without HY^{TM}-BWMS treatment, and two processes are started by two pumps simultaneously.
	3	Inspect whether the operation is stable after opening the management system of HY^{TM}-BWMS ballast water for 5 minutes and then inspect TRO of inflow water and ballast treatment water on sampling point.
	4	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 3 minutes. Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	5	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 19 minutes.Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	6	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 35 minutes.Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	7	Close the water pump of control cabin after control cabin 1 is filled with 220 m^3 of inflow water.
	8	Close the management system of HY^{TM}-BWMS ballast water after ballast cabin 1 is filled with 260m^3 of inflow water.

	9	Provide the water allocation tank in case that the test cycle 2 applies.

D1 Ballast 2	1	Provide the water allocation tank and use the sampler to take water and inspect whether inflow water fulfills G8 requirements.
	2	Start the test for second cycle of ballast treatment: A part of inflow water flows into ballast cabin 2 after HY^{TM}-BWMS treatment in the water allocation tank; The other part of water flows into control cabin 2 directly without HY^{TM}-BWMS treatment, and two processes are started by two pumps simultaneously.
	3	Inspect whether the operation is stable after opening the management system of HY^{TM}-BWMS ballast water for 5 minutes and then inspect TRO of inflow water and ballast treatment water on sampling point.
	4	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 3 minutes. Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	5	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 19 minutes. Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	6	Gather the water sample of inflow water and ballast treatment water after management system of HY^{TM}-BWMS ballast water runs stably for 35 minutes. Gather 22 L inflow water and 1.2 m^3 of ballast treatment water.
	7	Close the water pump of control cabin after control cabin 2 is filled with 220 m^3 inflow water.
	8	Close the management system of HY^{TM}-BWMS ballast water after ballast cabin 2 is filled with 260m^3 inflow water.

D5 Unloading 1	1	Clean the pipeline system of seawater input pipeline.
	2	Start the test for first cycle of unloading treatment.
	3	Inspect whether the operation is stable after opening management system of HY^{TM}-BWMS ballast water for 5 minutes, and then inspect TRO of discharging water before and after unloading treatment on the sampling point. Start to gather the discharging water before and after unloading treatment and water sample of discharging water from control cabin after the system runs stably for 3 minutes. Gather 1.2m^3 for each kind of water sample.
	4	Gather the discharging water before and after unloading treatment and water sample of discharge water from control cabin after management system of HY^{TM}-BWMS ballast water runs stably for 19 minutes.Gather 1.2 m^3 for each kind of water sample.
	5	Gather the discharging water before and after unloading treatment and water sample of discharge water from control cabin after the management system of HY^{TM}-BWMS ballast water runs stably for 35 minutes.Gather 1.2 m^3 for each kind of water sample.
	6	Close the management system of HY^{TM}-BWMS ballast water after completing the sample gathering.

	7	Test for preparation of concentrated water sample
	8	Move the sampling hose and sampling container so as to prepare for next test cycle.
6		Clean all test tanks (disposal and water supply tank) and sampling vessel.

D6 Unloading 2	1	Clean the pipeline system of seawater input pipeline.
	2	Start the test for second cycle of unloading treatment.
	3	Inspect whether the operation is stable after opening the management system of HY^{TM}-BWMS ballast water for 3 minutes, then inspect TRO of discharge water before and after unloading treatment on sampling point. Start to gather the discharge water before and after unloading treatment and water sample of discharge water from control cabin after the system runs stably for 5 minutes.Gather 1.2 m^3 for each kind of water sample.
	4	Gather the discharging water before and after unloading treatment and water sample of discharge water from control cabin after the management system of HY^{TM}-BWMS ballast water runs stably for 19 minutes. Gather 1.2 m^3 for each kind of water sample.
	5	Gather the discharging water before and after unloading treatment and water sample of discharge water from control cabin after the management system of HY^{TM}-BWMS ballast water runs stably for 35 minutes. Gather 1.2 m^3 for each kind of water sample.
	6	Close the management system of HY^{TM}-BWMS ballast water after completing the sample gathering.
	7	Test for preparation of concentrated water sample
	8	Move the sampling hose and sampling container so as to prepare for next test cycle.
6		Clean all test tanks (disposal and water supply tank) and sampling vessel.

6. Sampling Design and Arrangement

6.1 Regulation of sample numbering

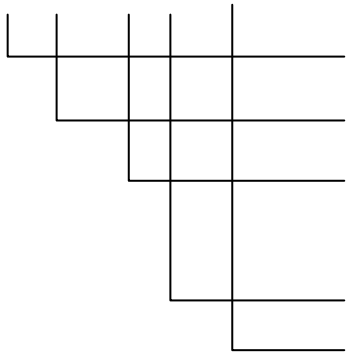
The test shall be carried out in two groups, covering 10 cycles in total. In the process of the whole test, samples with different times and different quantities and different test objectives shall be respectively and scientifically numbered to avoid the sample confusing and guarantee the authenticity and validity of the test data.

The implication presented by each letter or figure is specified in Table 4.1.

Category	Description
Test grouping	SH: Salinity＞32 PSU; SL: Salinity≤22 PSU
Test cycle No.	1,2,3,4,5
Category of gathered water sample	1: Inflow water with ballast 2: Treated water with ballast 3: Discharged water before unloading treatment 4: Discharged water after unloading treatment 5: Discharged water in control cabin
Different sampling time	B: Initial stage; M: Intermediate stage E: Ending stage
Analyze the water for different parameters	a: ≥50μm biology; b: 10～50μm biology; c: Microorganism; d: Water quality

Tag, numbering and style of test sample for ballast water treatment

S×T×-×× / ×



Description

Test grouping category SH: ＞32 PSU, SL: ≤22 PSU

Test cycle number 1, 2, 3, 4, 5

Category of gathered water sample 1: Inflow water; 2: treated water, 3: Discharged water from treatment cabin before unloading treatment; 4: Discharged water from treatment cabin after unloading treatment; 5: Discharged unloading water in control cabin

Sampling time B: Initial stage, M: Intermediate stage, E: Ending stage

Water quality analysis & Biology water a: >50μm; b: 10～50 μm; c: Heterotrophic bacteria; d: Water quality analysis

Example 1

Discharged water in high salinity group (＞32 PSU) from treatment cabin before the second cyclic unloading treatment≥50μm sampling number of biology on the ending stage: SHT2—3E/a

Example 2

Inflow water in low salinity group in control cabin in the 5th cycle (≤22 PSU) 10～50 μm sampling number of biology in the initial stage:SLT5—1B/b

6.2 Sampling time, site and efficiency obtained by sample

In the test of the whole continental rise, the sampling process shall be witnessed by the on-site surveyor. The witnessing surveyor shall seal the samples on site and note the sampling time on the strip seal. The actual sampling time shall also be recorded in the sampling record.

As shown in Fig. 6.1, based on the requirement of G8, 6 sampling points in total should be set for this continental rise test, such as, A, B, C, D, E and F. Therein, point A shall be sampled by hydrophore, and sampling at all other points shall be carried out from pipeline. The specific sampling purposes for each sampling point is described as follows:

Point A: sampling analysis shall be conducted for test water to guarantee whether the mixed water is in accordance with the requirement of G8;

Point B: take sample from ballast inflow water;

Point C: take sample from ballast treating water;

Point D: take sample from discharged water before unloading treatment;

Point E: take sample from discharged water after unloading treatment;

Point F: take sample from discharged water in the control cabin;

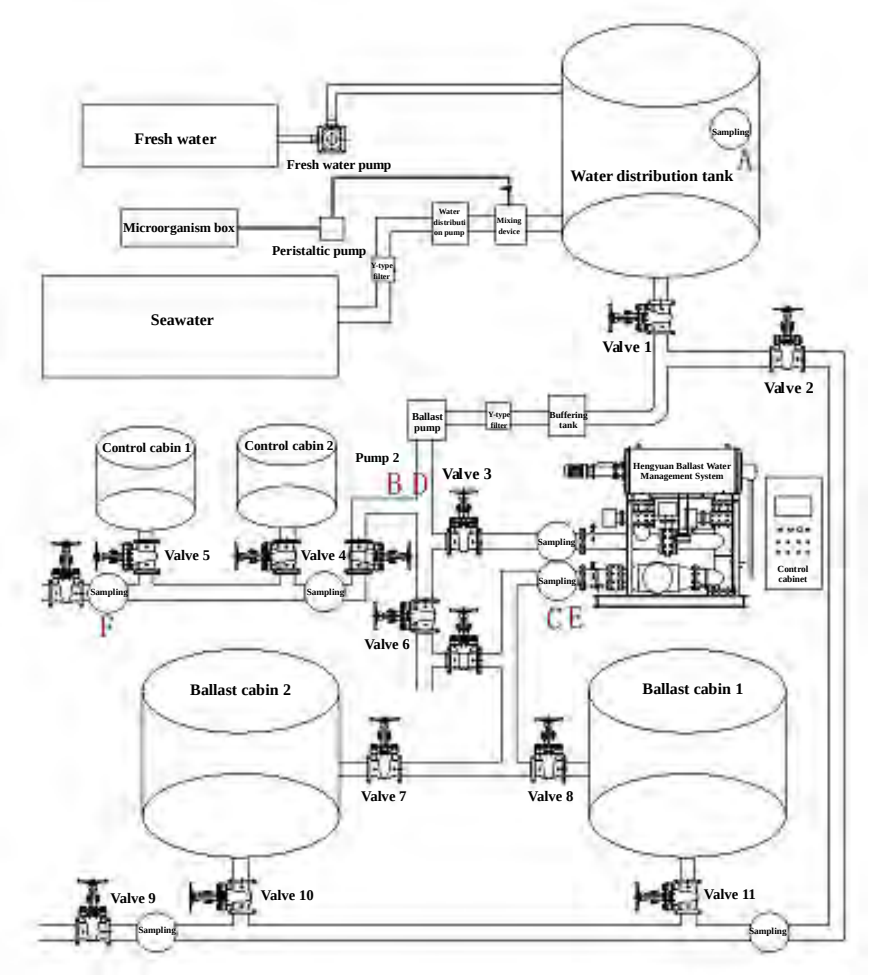


Fig. 6.1 Sampling point

During the ballast and unloading period, the time, location and quantity for each sampling are determined by different requirements of the test items. The sampling time, specification and quantity on different test stages are listed in Table 4.2. In this test of continental rise, PE bucket with a capacity of 22L shall be used to sample the ballast inflow water, and sampling at other sampling points shall be conducted with PE bucket with capacity of 1.2m^3,as shown in Fig. 6.2.

Fig. 6.2 PE bucket used for sampling and sampling site

Table 6.2 Time, Location and Quantity of Sampling in the Process of Test.

Category		Sampling time (min)	Volume and quantity				Sampling point
			≥50μm organism	10～50μm organism	Microorganism	Water quality analysis	
1	Ballast Inflow water	03:00～10:00	20 L	1 L	500 mL	2 L	B
		19:00～26:00	20 L	1 L	500 mL	2 L	
		35:00～42:00	20 L	1 L	500 mL	2 L	
2	Ballast Treated water	03:00～18:00	1 m^3	10 L	500 mL	2 L	C
		19:00～34:00	1 m^3	10 L	500 mL	2 L	
		35:00～50:00	1 m^3	10 L	500 mL	2 L	
3	Unloading place Discharged water before treatment	03:00～18:00	1 m^3	10 L	500 mL	2 L	D
		19:00～34:00	1 m^3	10 L	500 mL	2 L	
		35:00～50:00	1 m^3	10 L	500 mL	2 L	
4	Unloading place Discharged water after treatment	03:00～18:00	1 m^3	10 L	500 mL	2 L	E
		19:00～34:00	1 m^3	10 L	500 mL	2 L	
		35:00～50:00	1 m^3	10 L	500 mL	2 L	
5	Control cabin Discharged water	03:00～18:00	1 m^3	10 L	500 mL	2 L	F
		19:00～34:00	1 m^3	10 L	500 mL	2 L	
		35:00～50:00	1 m^3	10 L	500 mL	2 L	

6.3 Data record by monitoring instrument and gauge during testing

In the process of test, the working parameters of the ballast water treatment device shall be recorded, for example, current, voltage, power consumption and flow. As shown in Table 6.3, the record of these parameters shall be conducted during the sampling period in the process of test. These parameters shall be recorded by the designated personnel in the Hengyuan Marine Equipment Co., Ltd, and shall be conducted in the presence of the surveyor.

For example: according to above rule for sample numbering, the parameters recorded in the SHT-1b1 column in Table 4.3 indicate the record made within the time of first sampling for treated water at the initial stage within the first test cycle period in the test group with salinity >32PSU.

Table 6.3 Data Record Sheet during Each Test Cycle Period

Test project	Test cycle	Voltage (V)	Current (A)	Power consumption (KW)	Average flow rate (m^3/h)	Differential pressure and pressure at the input port and output port of equipment	Recorder	Witnessing surveyor	Time

						(MPa)			
Treatment cabin	SHT-1b								
	SHT-1m								
	SHT-1e - - -								
Control cabin	SHC-1b								
	SHC-1m								
	SHC-1e - - -								

7. Collection, Transfer and Detection of Samples

The sample testing for this test shall be undertaken by the First Institute of Oceanography, SOA, after being collected and concentrated according to the flow, the sample shall be transported back to the laboratory in Qingdao for testing, and the testing for all samples must be completed within 6 hours after sampling. While performing the analysis and testing for samples, the First Institute of Oceanography, SOA should verify whether there is the mark for sealed sample by witnessing surveyor on the sample, and the record should be performed properly as well as the note should be conducted in the report.

7.1 Test parameters

Based on G8 requirement, test the following parameters:

(1) Water quality: temperature (temperature), salinity (salinity), pH, dissolved oxygen (DO), turbidity (turbidity), dissolved organic carbon (DOC), particle organic carbon (POC), total suspended particulates (TSS).

(2) Organisms: Organism ≥50μm (mainly refer to zooplankter), Organism ≥10~50μm (mainly refer to phytoplankton)

(3) Microorganism: Heterotrophic bateria, Escherichia coli, Enterococcus faecalis and Vibrio cholerae

7.2 Collecting, treating, testing and storage for sample

The water from each experimental cabin shall be drained into PE bucket that is prepared (attached with label properly) and washed properly one by one in advance. The sampling taking from the large plastic bucket shall be performed for water sample to be analyzed, respectively referring to:

7.2.1 Water quality

(1) Temperature, salinity: directly measure at the sampling mouth of water distribution cabin, or measure in the vessel by employing the water sampler.

(2) Turbidity: directly measure by the multi-parameter analyzer jointly with temperature and salinity (or measure by spectrophotometer in the laboratory for sampling).

(3) pH: the water sample is poured into 100ml flasket to perform the onsite testing, each sample has three parallel samples.

(4) DO: it is poured into special brown DO sample flasket and the fixing agent is added to perform the indoor testing on the site.

(5) POC: the water sample is filtered by GF/F that is scorched (the filtering volume is determined based on the density of suspended matters and suspending biology), the sample on the filtering membrane is folded and packaged properly by the aluminum foil as well as numbered and stored in freezing under -20°C. When the long-distance transportation is within 12 hours, the sample must be stored in the dry ice or the freezer where the dry ice is placed as well as transported back to laboratory and put into the low-temperature freezer for awaiting test.

(6) DOC and TSS: 2L water is sampled and filtered by GF/F glass fiber filtering membrane that is scorched with 450°C and weighed (the filtering volume is determined based on the density of suspended matters and suspending biology), the sample on the filtering membrane is folded and packaged properly by the aluminum

foil as well as numbered and packaged by the sealed plastic bag. The sample is transported back to the laboratory and baked for over 12 hours in 60°C oven as well as weighed. The filtered water sample (DOC) is installed into the flasket via acid soaking and washing as well as transported back to the laboratory for testing.

7.2.2 Marine organisms

(1) ≥For 50μm biology (mainly referring to zooplankter), 1m^3 water sample is filtered by 50μm sieve at the sampling point of water distribution cabin, and the microscope is employed to directly perform the observation and appraise the counting. If the quantity of sample is too much, the activity condition of biology may be observed firstly under the microscope, the record should be performed properly and the medium dyed red is added as well as stored in freezing under -20°C. After unfreezing when returning to the laboratory, the counting is appraised in accordance with coloring degree.

(2) 10～50μm biology is filtered by 10μm sieve at the sampling point of water distribution cabin (1L sampling for inflowing water; 10L sampling for treated water and contrasted water), the inverted microscope is employed firstly to directly observe the status of living organism for cell, and then formaldehyde (2% for final concentration) or Lugol iodine solution(1% for final concentration) is employed for fixing and transported back to laboratory for appraisal and counting. The sub-sample shall be taken from each sample for three times for appraisal and counting.

The fluorimeter is employed to test the fluorescence of living organism for phytoplankton, or the chlorophyll is leached or PAM fluorimeter is employed to test the photosynthesis activity.

7.2.3 Microorganism testing

The sterile gathering must be taken for microorganism sample, and the sample must be subject to high-temperature sterilization. Take 500ml by 500ml glass flasket with high-pressure sterilization and respectively perform the measuring and taking according to the water sample quantity required by various floras after returning to the laboratory. Within two hours after sampling, implement the inoculated culturing. If the inoculated culturing can’t be completed within two hours, the sample should be put into the refrigerator or ice box for temporary storage, and the storage period can’t exceed 24 hours.

The sampling shall be performed at the sampling point and respectively put into the culture medium for various s according to the operating method for various floras, the detailed operation shall be conducted in accordance with the ocean monitoring specification.

7.2.4 Control on sample gathering, transferring and testing time

The onsite sampling time is controlled within 2 hours, the time from sampling site to testing laboratory is controlled within about half an hour. After reaching the laboratory, immediately begin the testing, the time is controlled within 3 hours, and the total time is controlled within 6 hours.

7.3 Testing method

7.3.1 Water quality parameters

(1) Temperature: direct measurement by the inductive probe for temperature by multiparameter water quality meter.

(2) Salinity: direct measurement by the inductive probe for temperature by multiparameter water quality meter.

(3) pH: Potentiometry method

(4) Turbidity: Direct measurement by the multiparameter turbidity probe;

(5) Dissolved oxygen (DO) : iodometry

(6) Total Suspended Solids (TSS): Weight Method

(7) Dissolved Organic Carbon (DOC): High-temperature combustion method

(8) Particle Organic Carbon (POC): High-temperature combustion method

7.3.2 Biological parameters

(1) Biology ≥50μm: Employ the little sieve made by 50μm silk sieve to filter a certain amount of water body or vertically drag and concentrate. While being analyzed, perform the appraisal and counting wholly, or the sample spliter is employed to divide it into equal volume, and take equal sample for appraisal and counting. and then convert it as individual number for 1L water.(Pc./m^3).

$$C_B = \frac{N_B}{V}$$

Where:

CB——individual density of zooplankton in the seawater with unit volume, unit: (ind/m^3);

NB——number of whole sieve, unit: Pc. (ind or cells);

V——Quantity of water filtering unit: (m^3).

(2) Biology 10~50μm: Employ the little sieve made by 10μm silk sieve to filter 10L water body. While being analyzed, demarcate it up to certain volume based on the cell concentration, and then, take the uniform sample into the counting plate (frame)for appraisal and counting. convert it as number for 1L water cell. (Pc./L or cells/L). The computation formula is as follows:

$$C = \frac{n \cdot V_1}{V_2 \cdot V_n}$$

Where:

C——Amount of specimen in the seawater with unit volume, unit: number of cell in 1L water; (cells/L);

n——Number for sampling and counting, unit: Pc. (cells);

V1——Volume after concentration of water sample, unit: ml (ml);

V2——Quantity of water sample filtered by the little sieve, unit: L (L);

Vn——Volume for sampling and counting, unit: ml (ml).

(3) Heterotrophic bacteria: Panel technology method

Principle: The plate counting method means that the single heterotrophic bacteria may form a visible daughter-cell population (bacterial colony) via cultivation for certain period on the basis that the single

heterotrophic bacteria locates on the panel culture medium, namely, a bacterial colony represents a bacterial cell, and the quantity of heterotrophic bacteria may be known via calculating the quantity of bacterial colony. The counting key is that the heterotrophic bacteria in the sample must be dispersed as single cell as much as possible and prepared as the uniform diluent with different concentration, and a certain amount of diluent is uniformly inoculated onto the petri dish filled with solid medium.

Method: Add 1ml Twain solution according to 100ml water sample, fully mix it uniformly so as to ensure that the heterotrophic bacteria in the sample disperses and presents the single cell. The aseptic manipulation method is applied to suck up 1ml water sample and inject it into 9ml test tube to sterilize the previous seawater as well as continuously dilute it up to required dilution by adopting the same method, three parallel samples are required for each kind of dilution. Take 0.1ml diluted water sample and inoculate it onto the culture dish filled with solid medium (2216E), uniformly daub the bacterium solution with sterilized glass rod. Put the nurture dish into the incubation box with 25°C constant temperature for 7-day cultivation, take it and count the quantity of bacterial colony.

(4) Vibrio cholerae: panel technology method

The total of vibrio is one of important parameters to reflect the pollution degree of pathogenic microorganism for water body, the TCBS panel selective cultivation medium is adopted to test the total of vibrio. After sample inoculating, the sample shall be cultivated under appropriate temperature to count the bacterial colony with vibrio feature and perform further appraisal and conformation.

Method: The aseptic manipulation method is applied to inoculate the water sample with three kinds of different dilution (10-1 and 10-2) into the test tube of BTB cultivation solution by applying ‘ MPN’ method and cultivate for 18 hours under 37°C, separate the bacterial solution in the positive tube on TCBS panel by marking the line and put the panel into the incubator under 37°C for 18-hour cultivation, inoculate the appeared green, blue-green and yellow culture onto the CPA bevel, the separated bacterial strain shall be subject to gram coloring, oxidase, moveability and 0/129 vibrio rope sensitivity test firstly. The bacterial strain conforming to the vibrio feature shall be calculated on the basis of pipe quantity for originated “MPN” and checked in “MPN” table.

(5) Coliform bacteria testing: filtering membrane method

Inject the water sample into the filter that has been sterilized and placed with micropore filtration membrane. Subject to suction filtration, the heterotrophic bacteria is withheld onto the filtration membrane, and then, the filtration membrane is tightly pasted on the appropriate selective cultivated medium for cultivating. After certain period of time, count and appraise the coliform bacterial colony growing on the filtration membrane, convert as the coliform bacterial colony included in the water sample per litre.

Method: Inject 100ml sample into the filter that has been sterilized and placed with micropore filtration membrane (cellulose acetate filtration membrane with 0.2μm in aperture). Subject to suction filtration, the heterotrophic bacteria is withheld onto the filtration membrane, and then, the filtration membrane is tightly pasted on the appropriate selective cultivated medium (M-TEC) for cultivating, invert the panel and put it into 37°C incubator for 0.5-hour cultivating and then move into 44°C incubator for 18~24 hour cultivating Count and appraise the coliform bacterial colony growing on the filtration membrane, count the coliform bacterial colony included in the water sample per litre.

(6) Enterococcus

PSE selective cultivated medium with agar panel is adopted for testing the total of enterococcus. After the

sample is inoculated, cultivate in 37°C incubator for certain period of time, calculate the bacterial colony with enterococcus characteristic and conduct the further appraisal for separation and purification.

The method is same as that of escherichia coli

Table 8.1 Test Parameters, Test Method, Sensitivity and Work Basis

Parameters	**Unit**	**MDL**	**Analysis method**	**Sensitivity**	**Basis**
Temperature	℃	NA	Probe of multi-parameter analyzer	0.1℃	Ocean survey specification
Salinity	PSU	1.0	Probe of multi-parameter analyzer	0.5 PSU	Ocean survey specification
pH	pH	0.0	pH meter method	0.01 pH	Ocean Survey Specification
Dissolved Oxygen	mg/L	0.1 0.2	Iodometry	0.05 mg/L	Ocean Survey Specification Ocean survey specification
Turbidity	NTU	0.1	Optical spectroscopy or turbidity probe for multi-parameter analyzer	0.1 NTU	Ocean survey specification
DOC(Dissolved Organic Carbon)	mg/L	0.36	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
POC(Partical Organic Carbon)	mg/L	0.1	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
Total Suspended Solid	mg/L	1.0	Weight method	0.1mg/L	Ocean survey specification
Organisms ≥50 μm	ind./m^3	1.0	Filtering and concentrating by 50μm screen, appraisal and counting by inverted microscope	ind./m^3	Ocean survey specification
Organisms ≥10~50 μm	ind./mL	1.0	Filtering and concentrating by 10μm screen, appraisal and counting by inverted microscope	cell/mL	Hallegraeff. Anderson and Cambella
Escherichia coli	CFU/100mL	1.0	Filtering membrane method	CFU/100mL	Ocean Survey Specification
Intestinal Enterococci	CFU/100mL	1.0	Fecal *Streptococcus* and *Enterococcus* group Filtering membrane method	CFU/100mL	Standard Method 9230 orMM-FS-CNJ-0351 (Inspection method for enterobacteria of exported commodities) or ISO4833-2003
Vibrio cholera(Serotype O1 and O139)	CFU/100 mL	1.0	Plate method	CFU/100mL	Ocean Survey Specification

7.2 Equipment and instruments

No.	Description	Specification	Scope and precision	Place of production
1	Plankton sieve	25cm in diameter of sieve opening	Aperture 50μm	Self-made, the silk screen originates from USA--USA
2	Plankton sieve	25cm in diameter of sieve opening	Aperture 50μm	Self-made, the silk screen originates from USA--USA
3	Precise acidity meter	PHS-3C	0～14 0.01pH	Shanghai China
4	Electronic scale	ME614S	0～610g 0.1mg	德国赛多利斯 Sartorius, German
5	Total organic carbon analyzer	TOC-VCPH	0.028mg/l	Nikon, Japan
6	Fluorescence microscope	EC501	1000×	Nikon, Japan
7	Inverted fluorescence microscope	TE2000-U	400×	Nikon, Japan
8	Inverted microscope	TS100	400×	Nikon, Japan
9	Anatomical lens		200×	OPTON, West Germany
10	Microcomputer counter	MCC1-1	100×3 10 60 100	Qingdao, China
11	Leaching device	250ml，500ml		Qingdao, China
12	Multi-parameter water quality meter	YSI6600		USA
13	Multi-parameter water quality meter	HydroLab H5		USA

8. Quality Assurance Plan of Project

8.1 Quality system

Execution shall be performed according to the terms of quality guarantee outline for sample testing during shore-base test procedure for HYTM-BWMS 200t ship's ballast water

Table 8.1 Test Parameter, Test Methods, Sensitivity and Work Basis.

Parameters	Unit	MDL	Analysis method	Sensitivity	Basis
Temperature	℃	NA	Probe of multi-parameter analyzer	0.1℃	Ocean survey specification
Salinity	PSU	1.0	Probe of multi-parameter analyzer	0.5 PSU	Ocean survey specification
pH	pH	0.0	pH meter method	0.01 pH	Ocean Survey Specification
Dissolved Oxygen	mg/L	0.1 0.2	Iodometry	0.05 mg/L	Ocean Survey Specification Ocean survey specification
Turbidity	NTU	0.1	Optical spectroscopy or turbidity probe for multi-parameter analyzer	0.1 NTU	Ocean survey specification
DOC(Dissolved Organic Carbon)	mg/L	0.36	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
POC(Partical Organic Carbon)	mg/L	0.1	High-temperature combustion method	0.02mg/L	Ocean Survey Specification
Total Suspended Solid	mg/L	1.0	Weight method	0.1mg/L	Ocean survey specification
Organisms ≥50 μm	ind./m^3	1.0	Filtering and concentrating by 50μm screen, appraisal and counting by inverted microscope	ind./m^3	Ocean survey specification
Organisms ≥10~50 μm	ind./mL	1.0	Filtering and concentrating by 10μm screen, appraisal and counting by inverted microscope	cell/mL	Hallegraeff. Anderson and Cambella
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			method		enterobacteria of exported commodities) or ISO4833-2003
Vibrio cholera (Serotype O1 and O139)	CFU/100 mL	1.0	Plate method	CFU/100mL	Ocean Survey Specification

8.2 Equipment and instruments

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7	Inverted fluorescence microscope	TE2000-U	400×	Nikon, Japan
8	Inverted microscope	TS100	400×	Nikon, Japan
9	Anatomical lens		200×	OPTON, West Germany
10	Microcomputer counter	MCC1-1	100×3 10 60 100	Qingdao, China
11	Leaching device	250ml，500ml		Qingdao, China
12	Multi-parameter water quality meter	YSI6600		USA
13	Multi-parameter water quality meter	HydroLab H5		USA

8.3 Quality guarantee measures

8.3.1 Quality guarantee measures for onsite sampling

All samples shall be collected at the testing site. The collected water sample shall be subpackaged into the sample bottles for each testing item, and each sample bottle shall all be pasted with label and identification. In order to prevent and reduce the contamination, the sample bottles shall be washed by hydrochloric acid (except for PH) in advance and then washed in the pure water. Before sampling, the bottles shall be washed twice by the onsite seawater sample. The microorganism sample bottle shall be subjected to the autoclaved sterilization in advance.

Each microorganism medium shall be prepared in the laboratory in advance and taken to the site for disinfection. The microorganism exceeding 50μm shall be filtered and concentrated on site by the mesh made from 50μm sieve silk and then put into the sample bottles. The microorganism with a size of 10μm~ 50μm shall be shall be filtered and concentrated on site by the mesh with made from 10μm sieve silk and then put into the sample bottle.

8.3.2 Quality guarantee measures of sample saving and transportation.

The anti-pollution measures shall be taken into the process of sample filtration and subpackaging. POC, DOC and microorganism sample must be operated with gloves. The sample which could not be analyzed on site shall be saved by frozen (chlorophyll a, dissolved organic carbon and Particulate Organic Carbon) after pretreatment and put in the dry ice during the transportation. The plankton shall be properly sealed and then hauled to the laboratory.

8.3.4 Quality control

8.3.4.1 Quality control on analytical test

- The instruments used for various tests all shall meet the project requirements.
- Before the sample is tested, at first, check the sample, requirements: the inside and outside marking of the sample shall be in accordance with the on-site sampling record and be complete.
- After the sample analysis, the analytical and detecting instruments must be kept under normal status.
- When there is unusual for the analysis results and detecting analysis, the reason shall be timely analyzed to conduct the reasonable analysis and conclusion, if necessary, all the analysis and detection shall be repeated again.
- Except for the postgraduates, the personnel for analysis and test shall hold the on-post certificate for marine environmental monitoring Although the postgraduates have the on-post certificate, but they shall be subjected to the on -job training which is professionally tested and training guidance before the project is tested.

8.3.4.2 Quality control for testing process.

Carry out the technical disclosure to all testing personnel, clear and definite responsibilities and quality responsibilities for each job.

After the instruments and equipment enter into the site, check whether the instruments and equipment are normal; After the instrument installation is in position, check, correct/ calibrate it again and keep records;

The operator shall operate the instruments according to the satisfactory specification, standard stipulations with valid version;

After the observation is completed, check whether the instrument is in the normal condition;

If the testing is interrupted due to the fault or the operation is required to be changed, the situation shall be reported to related leader, and after obtaining the approval, the change could be implemented.

8.3.4.3 Control of checkout equipment

All used instruments and equipment shall be authenticated by the national statutory authority and guaranteed to be operated with the effective period. Before self-inspection instruments are put into operation, each professional staff shall implement the comparing and testing calibration.

8.3.4.4 Filling of original record

1) The original record is the factual record of the testing result and is not allowed to modify or delete, and the original sampling record shall be signed after being witnessed by surveyor from Classification Society.

2) The format of original record is uniform and couldn't be filled by pencil (unless otherwise there is stipulation), and the r contents shall be filled completely with the signature by the tester and corrector

3) The confirmation of significant digit for test data and data processing must be strictly implemented according to the stipulation of GB/T-12763-2008 Standard and *Ocean Monitoring Specification*

9. Emergency Plan

Dispose the unexpected cases prior to and during the test according to emergency plan. Treatment principle in an emergency is that personnel security comes first and the protection of property and environment follows so as to minimize the losses as much as possible. Record for any case presenting in test process and analyze the causes seriously to get the solutions. Solutions to specific problems occurred in the test refer to Table 7.1.

Table 7.1 Solutions under emergency condition

Cases	Response solutions
1. Power failure of main power source	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency condition. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
2. Malfunction of ballast pump	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
3. Malfunction of fresh water pump, water allocation pump and peristaltic pump	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency. 4. Remove fault. 5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
4. Malfunction of UV module	1. Stop the system urgently. 2. Stop test procedure. 3. Consult the controller for alarm information and fault information in an emergency. 4. Remove fault.

	5. Inspect the preparatory situation of the test. 6. Confirm the test performed in an emergency. 7. Restart the test.
6. Personnel injury	1. Send injuries to the nearest hospital timely. 2. Assign new staffs.

10. Testing Basis

1) Approval guideline of ballast water management system G8 (MEPC.174 (58) Decision)

2) Sub Committee on Bulk Liquids and Gases IMO 15th session Agenda item 5. 12/2010.Development of guidelines and other documents for uniform implementation of the 2004 BWM convention, Additional guidance on indicative analysis

3) WMS Test Items & Test Standard for Type Approval of UV Disinfection System), Land-Based Test & Shipboard Test

4) The Fifth Part of Specifications for Oceanographic Survey, Ocean Chemical Investigation (GB/T12763.5-2007)

5) The Sixth Part of Specifications for Oceanographic Survey, Marine Organism Investigation (GB/T12763.6-2007)

6) The Fourth Part of Marine Pollution Monitoring Specification, Water Quality Monitoring and Analysis (GB17378.4-2007)

7) The Seventh Part of Marine Pollution Monitoring Specification, Offshore Pollution Ecological Investigation and Biological Monitoring GB17378.7-2007)

8) Manual on harmful marine microalgae, G.M Hallegraeff, D.M. Anderson and A.D. Cambella. Intergovernmental oceanographic commission. Manuals and Guides 33. 1995. Paris.